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THE AMERICAN

METEOROLOGICAL JOURNAL.

VOL. XI. BOSTON, MASS., MAY, 1894. No. 1.

METEOROLOGY AND GEODESY.

PROF. CLEVELAND ABBE.

SO long as the study of the weather maps for the prediction of the weather continues to be a purely empirical process in which we simply measure the progress of storms and cold waves for the past twenty-four hours and predict by assuming the same rate of progress for the next day, there is, of course, no need of a refined study into the dynamics of the atmosphere.

But the latter study has already been begun, first under the leadership of Ferrel and now under that of Bezold, Helmholtz, and other European physicists. It is not difficult to foresee that the generation of meteorologists that will soon succeed the present will struggle with mathematical questions as complex and numerical data as refined as those which at present occupy the attention of advanced astronomers and geodesists.

The general mathematical formulæ that have thus far been applied to atmospheric studies assume (1) that the earth is a sphere, and (2) that its surface is normal to the apparent force of gravity; it is further assumed by all who are at all critical, that (3) gravity varies systematically from the equator to the poles, and (4) also with altitude, but (5) that it is sensibly the same on all meridians. The first and second assumptions are inconsistent with each other; and the fifth has long been considered very doubtful, although the numerical extent of its uncertainty has only lately been measured. At present it is generally recognized that over the higher part of a large continent there is a very appreciable deficit in the force of gravity while over the deeper part of the ocean there is an excess.

Undoubtedly the continents were originally not only lighter as to density but weaker as to mechanical stiffness, so that they

began yielding under the strains caused by cooling, by tides in the crust, and by the weight of the denser strata under the ocean; they have continued to yield with the gradually increasing weight of the accumulating oceans notwithstanding the increased load of the strata deposited upon the continents. Thus the plateaus and mountains have been pushed up even higher than the location due to their density. The result is that neither the actual surface of land and water nor the ideal spheroid of Clarke is an equipotential surface: gravity is neither uniform over the earth's surface nor is it strictly normal thereto. After making due allowance for the attraction of whatever strata may be under the observer and above the ideal spheroid, there results a local attraction of gravitation (or a local weight of a unit volume of air at a standard temperature and pressure, or of a unit mass of air) that is less over the continents than it is over the oceans and is probably on the average less in the northern than in the southern hemisphere. Consequently if the atmosphere were at rest with regard to the earth's surface, and therefore in hydrostatic equilibrium, there would need to be a greater mass in the Northern Hemisphere than in the southern, and a greater mass over a given area of continent than over the same area of ocean, in order that the weights and pressures at the surface of the ideal spheroid might balance each other. But such accumulations of air could not exist without producing motions; even if static equilibrium were thus maintained in the lowest strata of air it would not exist in the upper strata or *vice versa*.

These differences of gravity must therefore produce a permanent stress in our atmosphere and this must be studied in combination with other stresses, such as those due to difference of density and to centrifugal force.

The geographical distribution of the force of gravity over the North American continent has recently been studied by our Coast and Geodetic Survey. During 1889 to 1893 Mr. E. D. Preston of this survey also made a number of measurements on islands in the Atlantic and Pacific Oceans. During the past year M. Commandant Defforges, of the French Geodetic Survey, made a few measurements in this country simultaneously with those of our own survey in order to be able to effect an accurate reduction of American and European measures to a common standard.

These results are combined in a recent article by Defforges (*Acad. Sci. Comptes Rendus, Paris,* 1894, CXVIII., page 229) from which I take the following: —

	Latitude.	Altit'e.	Observed Gravity.	Bouguer's Reduction to Sea Level.	Gravity at Sea Level.	G. calculated by Clairaut's Formula.	Departure. Obs. —Calc.	Ratio of Departure to Gravity.	Effect on Mercurial Barometer.
	Deg.	Meters.	Meters.	Meters.	Meters.	Meters.	Meters.		Inches.
Washington,	43.39	10	9.80167	+0.00002	9.80169	9.80142	+0.00027	+0.000028	—0.0008
Montreal,	50.57	100	.80769	+0.00018	9.80747	9.80715	+0.00031	+0.000032	—0.0010
Chicago,	46.46	165	.80345	+0.00030	9.80375	9.80386	—0.00011	—0.000011	+0.0003
Denver,	44.33	1645	.79684	+0.00299	9.79983	9.80216	—0.00233	—0.000238	+0.0071
Salt Lake City,	45.30	1288	.79816	+0.00234	9.80050	9.80293	—0.00243	—0.000248	+0.0074
Mt. Hamilton,	41.47	1282	.79583	+0.00233	9.79915	9.79991	—0.00075	—0.000077	+0.0023
San Francisco,	41.98	114	9.80016	+0.00021	9.80037	9.80030	+0.00007	+0.000007	—0.0002

The figures in the seventh column are the values of gravity observed at Paris, and reduced to sea level by Bouguer's formula, and then reduced to the latitudes of the present stations by Clairaut's formula.

The ninth column of this table shows that at Denver and Salt Lake City the deficit of gravity, after reduction to the ideal sea level, is still about 0.00025 of normal gravity as computed by Clairaut's formula, on the assumption that such coast line stations as Paris and Washington and San Francisco, are about normal One effect of this deficit is to make the mercurial barometer at Salt Lake City read 0.007 inch too high when the true pressure is 30 inches; if gravity is deficient, the mercurial column must weigh less, and a higher column will be sustained by a given pressure; since the aneroid barometer is not affected by gravity, therefore, at Salt Lake City, it will read 0.006 lower than the mercurial under a pressure of 25 or 26 inches. Again, the computations of elevations on the plateau using mercurial barometers at all the stations will give results that are too small. Again, the barometric observations on the plateau as reduced to sea level or any other plane will be too high; on the average of many years the normal distribution of atmospheric pressure varies but little, namely plus or minus 0.02 inch

throughout the length and breadth of our Rocky Mountain Plateau region, and the details of the distribution cannot be studied with any minuteness until the local pressures, the altitudes, and local forces of gravity are known with greater accuracy than at present. Finally, a deficit of gravity causes a diminution of atmospheric pressure over the plateau with respect to what it otherwise would be, and if the atmospheric mass is not correspondingly increased, then the air above the plateau will be less able to resist the pressure of air under normal gravity at the same level, pushing inward from the shores of the Atlantic and Pacific; there will, therefore, be a tendency toward an actual motion of the atmosphere inward from the east and the west.

The deficits of gravity over the Asiatic continent are presumably larger than in America. On the other hand, the force of gravity is in excess over the deeper parts of the Atlantic and Pacific Oceans at sea level, as shown by Defforges in the following table, which gives for certain stations in these oceans the same data as in the 8th, 9th, 10th columns of the preceding table: —

Atlantic Ocean.	Departure Obs.—Cal.	Ratio of Departure to Gravity.	Effect on Merc. Barom.	Pacific Ocean.	Departure Obs.—Cal.	Ratio of Departure to Gravity.	Effect on Merc. Barom.
	Meter.		Inch.		Meter.		Inch.
St. Thomas..	+0.00172	+0.000176	−0.0053	Ualau........	+0.00283	+0.000289	−0.0087
Ascension....	+0.00151	+0.000154	−0.0046	Guam........	+0.00197	+0.000201	−0.0060
St. Helena....	+0.00225	+0.000230	−0.0069	Mauwi........	+0.00180	+0.000184	−0.0055
Fernando de Noronha	+0.00196	+0.000200	−0.0060	Ile de France	+0.00224	+0.000229	−0.0069

The figures of these tables show that from the Sandwich Islands to Salt Lake City, and from St. Thomas to Denver, or about 40 degrees of a great circle, there is an abnormal diminution of gravity sufficient to produce a diminution of 0.014 to 0.016 inches of atmospheric pressure at sea level; corresponding to this the barometric pressure in a uniform atmosphere would at sea level diminish at the rate of 0.0003 or .0004 inch per degree. But this gradient is not uniform, its maximum value in the neighborhood of San Francisco is much larger, or about 0.0025 inch per degree of a great circle.

Small as it is, this gradient is quite appreciable in comparison with that required to overcome the viscosity of the air, which latter has ordinarily, but I think erroneously, been introduced as friction into the mathematical formulæ for atmospheric motion. I have shown in my "Preparatory Studies" that the principal resistance to the motion of the air originates in the convective processes that force stagnant air to mix with that which is rapidly moving, and thus retard the latter; this convective friction is quite independent of viscosity, and much more effective; it would exist in a so-called perfect fluid; it is as important in the flow of rivers as it is in the atmosphere; it follows a peculiar law of distribution, having its diurnal and its annual periods, and its geographical irregularities; to it I attribute the greater part of the diurnal variation of the barometric pressure.

If we neglect convective resistances, but introduce viscous resistances into our fundamental formulæ for atmospheric motions, then, in order to be consistent, we should also introduce the influence of the abnormal distribution of gravity as can be easily seen from the following considerations.

The known value of the co-efficient of viscosity, and the observed increase of wind velocity for each foot of ascent in the lower atmosphere, enable us to compute that the force required to overcome viscosity when the wind is blowing twenty-five miles an hour and at freezing temperature, will be furnished by a barometric gradient of 0.0013 inch per degree of a great circle.* If the force of gravity is considered as unity, the centrifugal force at the equator is $\frac{1}{289}$, or 3.39 dynes; the force

* The following computation is revised from pages 62 and 63 of my "Preparatory Studies": —

A barometric gradient of $1^{mm.}$ per degree G. C., is a gradient of $\frac{1014000}{760}$ or 1321 dynes pressure per square centimeter per linear degree, or, 0.00012 dyne per linear centimeter.

At a freezing temperature a shearing stress (whether a pull or a pressure) of 0.00018 dyne will overcome the viscosity and maintain a layer of air one centimeter square, in uniform motion when gliding at the rate of one centimeter per second, over a quiet layer of air one centimeter distant.

Therefore, a stress of 0.00012 dyne due to a barometric gradient of one mm. per degree will maintain a differential velocity of $\frac{12}{18}$ or 0.67 centimeter per second in layers one centimeter apart.

Converting into English measures: a gradient of 0.03937 barometric inch per degree will maintain a differential velocity of 0.26 inch per second, or 0.022 foot per second, or 0.015 mile per hour, in layers of air that are 0.3937 inch, or $\frac{1}{3048}$ feet,

required to overcome viscosity in the case here considered, is about one tenth part of the centrifugal force at latitude 60°, and almost precisely equal to the permanent stress due to the abnormal gravity gradient on the Pacific coast.

Undoubtedly the most important subject for the meteorologist to study at present is neither viscosity nor abnormal gravity, nor even centrifugal force, but rather convective mixtures, and the resistances or accelerations that result therefrom. After this latter study has explained the larger part of the irregularities of atmospheric motions, it will then be necessary to take up the minute but appreciable irregularities here treated of.

WASHINGTON, Feb. 22, 1894.

THE MAXIMUM PRECIPITATION OF SOUTHWESTERN NORTH CAROLINA, PARTICULARLY ON THE SOUTHERN AND EASTERN SLOPES OF THE BLUE RIDGE.*

ALFRED J. HENRY, U. S. WEATHER BUREAU, WASHINGTON, D. C.

THE isohyetal of eighty inches which skirts the southern and eastern slopes of the Blue Ridge on the annual rainfall map for 1893 expresses a *physical* fact that has been *recognized* for some time. Three rainfall registers for 1893 on and above the contour line of 3,000 feet have been furnished by the following voluntary observers of the Weather Bureau : —

MISS ALBERTINE STAUB, Highlands, Macon Co., N. C.
Lat. 35° 5′ N. Long. 83° 11′ W. Elevation 3,817 feet.
MR. D. F. STEARNS, Columbus, Polk Co., N. C.
Lat. 35° 15′. Long. 82° 10′. Elevation about 3,000 feet.
MR. BARRY C. HAWKINS, Horse Cove, Macon Co., N. C.
Lat. 35° 3′. Long. 83° 13′. Elevation about 3,000 feet.

apart. Or, again, a gradient of 0.0013 inch per degree will maintain a differential velocity of 0.015 mile per hour in layers that are one foot apart.

The observations of Stevenson and Archibald show that there is an increase of about 0.015 mile per hour in the velocity of layers one foot above each other in the lower atmosphere, and for winds of twenty-five miles per hour; this differential velocity would evoke a viscous resistance that can be overcome by the barometric gradient of 0.0013 inch per linear degree.

* By permission of the Chief of Weather Bureau.

Observations of rainfall in this part of North Carolina began in 1872 at Murphy, Cherokee County, elevation 1,544 feet. The full measure of the intensity of the rainfall on the exposed sides of the Blue Ridge was not definitely ascertained, however, until a year or so ago, when the observers above-named began reporting.

A word as to the topography of the counties of Cherokee, Clay, Macon, Jackson, Transylvania, Henderson, and Polk, in and adjacent to the area of eighty inches of annual precipitation above mentioned.

The general topographical features are varied and complex; mountain, plateau, and valley are intermixed in endless confusion. On the western border of the State is the great Smoky Mountain chain. Parallel with it and connected by a network of heavy cross chains, with innumerable spurs thrown off to the east and south, is the southern extension of the Blue Ridge. In a general view of the mountain system of western North Carolina the Smoky Mountains may be considered as the dominant chain with elevations ranging from 5,000 to 6,500 feet. The Blue Ridge in the southern part of Macon County, where two of the new rainfall stations are situated, does not possess the characteristic features of a regular well defined mountain system, but appears rather as a broken, irregular line along which the mountain table-land drops down rapidly to the level of the submontane plateau on the east and south.

Singularly enough the drainage of the plateau, between the two ranges, is to the westward, the streams rising in its eastern and lower border and breaking by deep chasms through the more elevated and massive western barrier. The drainage of the greater portion of Macon County is to the northward and westward into the Little Tennessee. The rainfall of this area as determined from about twelve years' observations at Franklin, N. C., elevation 2,141 feet, is about fifty-seven inches annually, almost the same as at Chattanooga, Tenn., on the other side of the main mountain chain. It possesses, in common with the rainfall of the latter, a principal maximum occurring in the late winter and early spring months, and a secondary summer maximum. The summer maximum, culminating in August at the majority of stations in North Carolina, is a characteristic of the rainfall of that State; it is most prominent at coast stations, and

is also well marked throughout the State to the western border. The winter maximum, however, is noticeable only at elevated stations in the western and southwestern part of the State, although there is a very general but small increase in the rainfall of March over that of February at almost all rainfall stations outside of the mountain districts.

As has been said before, the annual rainfall at Franklin is fifty-seven inches on the average; if, however, we go a few miles southward, to the ridge that forms the watershed of the Mississippi and the rivers that flow into the Atlantic, we find an average annual fall of between seventy-five and eighty inches, as determined from nine years' observations at Highlands, and two years' observations at Horse Cove. Observations at other points on the southern and eastern slopes of the Blue Ridge, as at Casher's Valley, Jackson County, elevation 3,800 feet, in 1881, 1882, and 1883, and at Columbus, Polk County, in 1892–1893, indicate that the heavy rainfall of southern Macon County is common to the high table-land extending about seventy-five miles or more in a northeasterly direction. Fragmentary observations made in McDowell County, at an elevation of 2,400 feet, indicate that there is a northward extension of the area of heavy rainfall. It is quite probable that such an extension does actually exist, although the amount of moisture precipitated is not so great as in more southern latitudes, being further removed from the source of moisture and the paths of low area storms originating in the Gulf of Mexico and the West Indies.

The town of Highlands is situated in a shallow basin surrounded by mountain peaks of varying altitude. It is apparently on the western side, and very close to the crest of a well defined cross chain running in a northwesterly direction.

The daily rainfall of Highlands, Horse Cove, and Columbus, N. C., and also of Atlanta, Ga., for 1893, the latter serving as a base or lower level station, has been examined in order to determine whether causes other than those generally recognized as contributing to an abundant rainfall, could be found. Nothing appears, however, at variance with what might be reasonably anticipated, if we exclude the rains with north winds at Columbus.

The prevailing winds at Highlands are from the west, the combined west, northwest and southwest winds being 57% of all the winds observed. The combined south, southeast and east

winds represent 40%, and the remaining three per cent is distributed between the south and northeast. Fifty-two per cent of the rains during 1893 occurred with south and southeast winds, and 32% with west and northwest winds.

Horse Cove, N. C., is supposed to be but a few miles to the southwest of Highlands, and in a valley opening to the southward. Mr. Hawkins reports a fall of 93 inches in 1892, and 73 inches in 1893. Both Highlands and Horse Cove are in the area drained by the head waters of the Chattooga which flows south into the Savannah River, although very near the line which divides the waters of the Atlantic and the Mississippi. The rainfall of this region has been determined, heretofore, from registers kept at Rabun Gap, Ga., elevation about 1,900 feet. The average fall at this place is 68.0 inches from nine years' observations. Atlanta, on the lower plateau, a short distance above the 1,000 foot level, is credited with an average annual fall of but 54.5 inches, from fourteen years' observations.

The third elevated station is on the Tryon Mountains, near Columbus, Polk County, N. C. Judging from the relative frequency of the winds, the station is apparently surrounded by mountains on all sides, except the north.

During 1893 there were more winds from the north than from all other directions combined, and the combined northwest, north, and northeast winds represent 83% of the total winds observed. The total precipitation at Columbus for 1893 was 87 inches, that of 1892 about 70 inches.

While the annual totals at these mountain stations are much in excess of the amounts registered at lower level stations, they are not wholly exceptional for North Carolina. The rainy year of 1877 gave over one hundred inches on the coast from Beaufort to Cape Hatteras, and the average annual fall at the latter point for the six years ending with 1880, was 79 inches.

Comparing the daily rainfall at Highlands, Horse Cove, and Columbus with the amounts registered at lower stations, it is found that there is no definite ratio between the upper and lower stations. The greatest differences are found in the case of West India hurricanes that approach land slowly and give copious rains for several days in succession. During the storm of September 7–13, 1893, there were registered 13.53, 12.78, and 9.79 inches of rain at Horse Cove, Highlands, and Columbus,

respectively, while at Atlanta the fall was but 2.20 inches. On the other hand we should not fail to notice that some of the heaviest rains occur with west and northwest winds. The ratio of west and northwest to south and southeast rain winds is as follows:—

Atlanta	8 : 10
Horse Cove	5 : 10
Highlands	6 : 10

If we compare the combined southwest, west, and northwest rain winds at Horse Cove with the combined northeast, east, and southeast rain winds we find that the ratio is 9 : 10, precisely the same as at Atlanta. At Highlands, however, the majority of rain winds are from some eastern quarter in the ratio above given, whatever combination we may make.

Forty-three per cent of the rains at Columbus, during 1893, were accompanied by north winds, in fact 75% of all the rains were accompanied by winds from some point between northwest and northeast.

THE SEA-BREEZE AT BOOTHBAY HARBOR, MAINE.

GEORGE B. MAGRATH.

THE phenomenon of the sea-breeze has been so carefully studied in the investigation* recently carried on, under the auspices of the New England Meteorological Society, by Prof. Davis and Messrs. Schultz and Ward, that I cannot expect to add much to the literature of the subject by stating the results of my own observations at Boothbay Harbor. The only justification of the following account is that it may be of some interest to those who are familiar with the subject of littoral winds and their occurrence.

Boothbay Harbor is formed by an indentation of the Maine coast, some ten miles east of the Kennebec River. A general southerly exposure lays open the lower part of the bay to the sweep of the prevailing southwesterly and stormy southeasterly winds; the inner harbor, however, is well sheltered. This fact, together with the general absence of shallows, sunken ledges,

* An Investigation of the Sea Breeze, by W. M. Davis, L. G. Schultz, and R. De C. Ward, Annals of the Astronomical Observatory of Harvard College, Vol. XXI., Part II.

and tidal currents, makes the harbor very popular with sea-faring people. The region is also very popular with summer visitors, and it is chiefly as a summer resident that I am acquainted with it.

In the summer of 1892, my interest in the subject having been awakened by the report of the investigation already mentioned, and a suggestive article* published in the JOURNAL giving an account of the sea-breeze at Cohasset, Mass., I began systematic observations of the occurrence of the sea-breeze at Boothbay Harbor. From what I have seen I am led to conclude that the normal conduct of the sea-breeze is best observed during July and August. In June the weather is often unsettled, and but few typical sea-breeze days occur during that month. In September the prevalent off-shore winds often prevent altogether the appearance of a sea-breeze.

Typical or normal occurrence of the sea-breeze is thus, as I have noted, best seen about mid-summer. At this time of year, under average conditions, the daily wind movement at Boothbay is as follows: An hour before sunrise it is usually calm; occasionally there is a remnant of the night land-breeze, which makes itself apparent in dark patches here and there over the otherwise unbroken surface of the harbor. This off-shore breeze, generally northwest, sometimes lasts long enough to carry the fishing boats to the outer grounds before sunrise. By the time the sun is an hour high, a breeze has usually sprung up from the north or north-northwest. This is the regular morning off-shore breeze, which gradually increases in force, at the same time shifting slightly to the eastward. It commonly reaches its maximum velocity about eight o'clock. From then until the middle of the forenoon it regularly diminishes, blowing fitfully in light squalls, and continually becoming more and more easterly in direction. By ten o'clock the surface of the outer harbor is usually calm; in-shore it is perhaps ruffled in scattered patches by the remnant of the land-breeze, which sometimes persists locally until the arrival of the sea-breeze.

It may happen that the land-breeze, instead of dying away, maintains its force, continuing to blow steadily from the north, or becoming easterly and southerly; in the latter case it merges

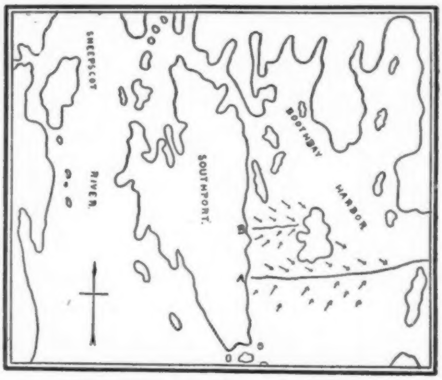
* The Sea Breeze at Cohasset, Mass., by W. C. Appleton, American Meteorological Journal, IX., 134-138.

into the sea-breeze. Such continuity in the "rotation" of the winds is, at Boothbay, rather the exception, a more or less general calm usually intervening between the disappearance of the land-breeze and the appearance of the sea-breeze. Between eleven and twelve o'clock, the bay then being calm, a narrow blue streak develops along the southern horizon, gradually widening until the whole surface of the bay is darkened by the short, crisp ripple of the sea-breeze. The character of this breeze is noticeable at once, especially if it comes at the end of a hot, close forenoon; upon its arrival there is usually a marked fall in temperature. By one o'clock the sea-breeze is usually well established, although, under certain conditions to be mentioned presently, it arrives much later in the day. When it first reaches the land, the direction of the sea-breeze is south or south-southeast, *i. e.*, it blows directly landward. Early in the afternoon, as the breeze gains in strength, it shifts constantly to the westward until it becomes southwest. In this quarter it holds for several hours, and then reaches its greatest velocity which is sometimes that of a "single-reef" breeze.

Under ordinary conditions, the breeze remains southwest until between four and five o'clock, when it again begins to veer to the westward, at the same time slowly losing its force. By sundown the breeze is west or west-southwest, and gradually dying out, so that at dusk the sea is quite calm. Rarely, the sea-breeze persists until the land-breeze begins, apparently merging into it. Thus, there are occasionally days on which the rotation of the winds is completed without any break in its continuity. Usually, the land-breeze begins about dark, from the west-northwest or northwest. Its character is easily recognizable in the early evening, especially on the water, where the observer feels now a warm gust of air that has lain near the earth, now a draught of colder air which has settled down from aloft.

The chief variation from this typical occurrence of this sea-breeze exists when the breeze comes unusually late in the day. This seems to take place under certain statable conditions, and presents interesting phenomena. I have often noticed that on very warm mornings the land-breeze is much stronger and more persistent than at other times. The same is also true when an area of high pressure is central over New England. Under either of these conditions the arrival of the sea-breeze is much

retarded. A particular case will make this clearer. July 20 1892, was at Boothbay a clear day with a maximum temperature of 78°. In the morning there was a brisk northwest, off-shore wind, which did not die away at the usual time, but persisted until long past the time for the arrival of the sea-breeze. At noon the northerly wind prevailed in the harbor with undiminished force, and it was only by watching vessels "outside" that an incoming sea-breeze could be detected. At one o'clock I set sail in my cat-boat and steered in a southerly direction, running before the fresh northwest breeze. When I had held this course some fifteen minutes, the boom of the boat suddenly swung inboard, showing that I had run out of the northerly wind. There was no calm streak, however; the surface of the water about me was everywhere rippled; but the wind seemed to blow from all quarters at once, making headway impossible. Behind me the bay was dotted with white-caps tossed up by a fresh northwest wind; less than thirty yards ahead a small sea was tumbling under a strong southerly breeze. I was caught between the winds, which came together on a "line" less than fifty yards wide,* and was actually obliged to row in order to reach the southerly wind. Outside, a choppy sea running from the southwest showed that the sea-breeze had been blowing there for some hours. When I returned to the harbor, late in the afternoon, I found that the sea-breeze had penetrated farther into the bay,† but had failed to reach the land, the land-breeze still persisting along the shore. The weather map for this day showed an area of high pressure central over New England, which accounted for the persistance of the land-breeze and the consequent checking of the sea-breeze.



MAP OF BOOTHBAY, MAINE, AND VICINITY.

* "A" of the sketch map. † "B" of the sketch map.

A more common cause of the retardation of the incoming sea-breeze is the rapid warming up of the land. When a forenoon is especially hot, the land-breeze retains its force until much later than usual, and the sea-breeze may be prevented from reaching the land until the middle of the afternoon. Upon such mornings, cumulus clouds, characteristic effects of rapid heating of the earth, form in great masses over the land, and, rising from the north, drift sea-ward. The weatherwise among the inhabitants of the region base their predictions as to the winds of the day upon the appearance or non-appearance of these clouds. They affirm that the clouds drifting sea-ward "kill" the sea-breeze, and that so long as these continue to form the sea-breeze will not appear, in this way confusing cause and effect in an odd manner.

The report upon the sea-breeze, already mentioned, makes note of the fact that littoral winds commonly combine with the prevailing winds of the region. This seems to be realized at Boothbay. Here, as elsewhere on the New England coast, the prevailing winds in summer are southwesterly. The sea-breeze when it first appears is generally south or south-southeast but it becomes more and more westerly until it reaches the southwest, in which quarter it remains longest and attains its greatest force.

It is commonly believed by the fishermen of Boothbay and its vicinity that the tides have an influence upon the sea-breeze. As the result of numerous observations I have found that there is some apparent relation between an ebb tide and the non-appearance of the sea-breeze, in that when the ebb tide comes in the afternoon the sea-breeze arrives much later than usual, or possibly not at all. This relation does not seem to exist in Boothbay Harbor itself, but I have noted its occurrence with great regularity in the wide estuary of the Sheepscot River, just west of Boothbay. Whether the relation is one of cause and effect I am not prepared to say; I feel sure, however, that in the case mentioned it is not purely accidental.

The accompanying sketch map shows the relative positions of Boothbay Harbor and the Sheepscot River, and also the direction of the winds on the afternoon of July 20, 1892; A shows the condition of the winds at 1.30 P. M.; B their condition at 4.30 P. M.

Harvard University, Cambridge, Mass., April 1, 1894.

CURRENT NOTES.

Weather Bureau Notes. — Secretary Morton has created a new division in the Weather Bureau to be known as the division of Agricultural Soils. Prof. Milton Whitney has been appointed chief of the new division. Prof. Whitney is well known in agricultural, educational, and scientific circles; and has been conducting investigations regarding the relations of climate and meteorological conditions to soils for some years, during which he has been connected with the Maryland State Experiment Station and the Johns Hopkins University. He was also for some time temporarily employed in the Weather Bureau, and in 1892 prepared a special report on "Some physical properties of soils in their relation to moisture and crop distribution," which was published as Weather Bureau Bulletin No. 4. The purpose of the new division is to pursue investigations of an analogous character — carrying the climatic observations of the Weather Bureau *into* the soil, where the moisture effects its work and makes its influence felt upon the plant life. The Secretary's order briefly defines the work as follows: —

"It shall be the duty of this division to study the climatic conditions of heat and moisture under the surface of the ground, and the relation of these conditions to crop distribution."

It is hoped that the work of the new division will result in acquiring a great deal of information of value to farmers on the character of soils in relation to the distribution of moisture to plants. The solution of the problems involved will serve to determine the adaptability of certain kinds of soil to certain crops by which the value of land may be greatly increased. Instances of this kind are strikingly furnished by the utilization for truck-farming in Maryland of lands unavailable for other crops, and which, as a result, have increased ten and twenty fold in value, and also by the adaptation in other States of certain soils regarded theretofore as worthless for tillage, but which, having been found to be of a nature suited to the production of certain varieties of tobacco, are now among the most valuable in their respective States.

Meteorological Problems for Mathematical Students. — The following extract from a recent letter by Prof. Cleveland Abbe, addressed to Prof. James MacMahon at Cornell University, may interest others who contemplate introducing meteorology into the graduate courses of study for the degree of Ph. D.: —

"You are, I suppose, the first in America to direct the attention of university students to the important and beautiful mathematical problems offered by meteorology. I have said something on this subject in the Johns Hopkins University Circular of June, 1892.

"In reply to your request for suggestions as to profitable lines of mathematical study, I would say the subject is full of such.

"1. The introduction of viscosity into the fundamental equations of the general motions of the atmosphere is unnecessary, as I have shown in my 'Preparatory Studies.' The resistances that Ferrel and other authors call friction is not fluid friction, or viscosity, as that term is used by the Germans and French, but it is the convective resistance, as I have above explained, and it exists whenever a rapidly moving fluid gives up a part of its momentum to a slower moving fluid, with which it intermixes. The friction term introduced into the equations should be expressed by a function such that it gives a positive pressure, namely, an acceleration at the earth's surface, diminishing with altitude until it becomes a negative pressure, or retardation, at the level of the cumuli and cirrus clouds and rapidly becomes zero above the altitude attained by convection currents. Moreover, it has a diurnal and annual and geographical variation ; at night time and in winter and in Arctic regions there is apt to be no convection in the lowest strata for several hundred feet above the earth's surface, and in such cases neither the viscosity nor the convective resistances are of any importance to meteorology.

"2. The problem of cyclonic motions treated of by Oberbeck, in the papers I have translated, have been supplemented by a short memoir by Pockels in the 'Meteorological Zeitschrift,' January, 1893, page 9, to which you should refer your students.

"3. The vortex problems solved by Mr. Chree, a list of which I have given in the Bulletin of the New York Mathematical Society, will also interest the students.

"4. In order to simplify the analysis, it has been customary to treat the atmosphere as a homogeneous, incompressible fluid; the expressions for viscosity, moisture, and density, as depending on temperature, have been introduced as a first step towards presenting the true problem of nature, but the earth's surface has been considered smooth, and the air incompressible. Now, in fact, all the important weather phenomena depend upon the irregularities of the earth's surface and the compressibility of the air; these features must be traced out to their ultimate results, and, in doing so, both the adiabatic and the non-adiabatic thermo-dynamic processes must be followed up. It is customary to resolve the mathematical equations under the assumption that the total quantity of heat in the atmosphere remains constant, so that there must be either a steady series of adiabatic changes by which the warming due to compression balances the cooling due to expansion, or else there must be a steady condition of flow of heat in at the tropics and out at the Arctics. But I think I have shown in the 'American Journal of Science,' April, 1892, that the loss of heat by radiation from the molecules of gas and vapor and dust, which, in general, we call atmospheric radiation, is the most important process going on in the air at altitudes above five thousand feet; this radiation must be introduced into the differential equations. Just how to do this seems to be snggested in a paper by Fourier, in a fragment written in 1820, but published after his death in 1833 (Memoirs of Acad. Sci., Paris, VII., page 507).

"5. The discussion between Ferrel and Airy on one side, and Sir Wm. Thomson on the other, as to the determination of the co-efficients of a certain series, has an important bearing on atmospheric tides and, in fact, on the whole theory of serial developments. I believe that Ferrel is altogether right, and I suspect that others are now inclined to agree with him. The first terms of equation 6, 'Mechanics of the Atmosphere,' page 320 depend upon the initial and boundary conditions, and in the case of atmospheric tides these control and destroy the free tidal wave. A *résumé* of this discussion between Ferrel and Thomson would be a very profitable thesis for your students.

"6. When a river or stream flows steadily over an obstacle, a series of standing waves is seen on the surface; analogous standing waves were observed by me to leeward of the island of Ascension, over which the southeast trade flows steadily. (See AMERICAN METEOROLOGICAL JOURNAL, 1891, VIII., page 263.) I suppose that illustrations of similar standing waves can be found everywhere, and that clouds on the leeward side of any mountain often represent the summits of similar sets of waves. A mountain chain, like the Rockies or Andes, is a very important feature in meteorology. Consider a general atmospheric upper current flowing from the southwest over Mexico, California, Oregon, Alaska; it pushes up over the summits of the ridge, and must form standing waves to an immense extent, probably covering the whole of North America. I suppose that Sir Wm. Thomson's article in 'Phil. Magazine,' XXII., on 'Stationary Waves in Canals,' will hardly apply to this case. Margules has published two papers on wave motion of the atmosphere (Vienna, Sitzb,, 1892–93), which touch upon similar problems, and show that waves moving westward must die out very rapidly as compared with those moving eastward; these papers will suggest to you many new problems for your students.

"7. The above items, 1 and 6, are, as you will easily see, closely correlated. As soon as we learn to introduce into the general solutions a boundary condition representing the fact that the earth's surface is a system of hills represented by a series of periodic terms, we shall then find that the solution of the equations will contain the convective friction and the standing waves.

"I fear I may have overdone the matter in this reply to your letter, since I have proposed difficult problems that may puzzle and discourage your students rather than stimulate them; but I am persuaded that they will be able to work out the solutions if you will encourage them to begin by experimenting with layers of water and oil, or of cold and warm air, or of carbonic acid gas and ordinary air; thus familiarizing themselves with the general conditions of the problems. Such experiments in what I call a 'Meteorological Laboratory' would be of the greatest benefit to the students of the higher meteorology."

It is certainly greatly to be desired that some friend of science will contribute to the development of meteorology and the education of a future generation of meteorologists, by establishing a laboratory of the kind suggested by Prof. Abbe.

The Magnetic Storm of Feb. 20 to March 1, 1894.—Lieut. C. C. Marsh, United States Navy, of the National Observatory, Washington, has sent to this Journal some interesting data regarding a magnetic storm noted at the Observatory from Feb. 20 to March 1. The magnetographs show the storm to have begun about 3.40 P. M., Feb. 20, and to have lasted, without any intermission, until 5 P. M., of Feb. 26. From that time until 7 A. M., of Feb. 28, the magnetic weather was calm, or about normal. The afternoon and evening of Feb. 28 were much disturbed, and all of March 1, though in a less degree, until midnight.

Between 6.45 and 8.20 A. M., on Feb. 21, there was a westerly disturbance amounting to 34′ of arc, and between 5.30 P. M., of Feb. 22, and 3.30 A. M., of Feb. 24, the needle was in violent motion. At one time, between 10 and 10.10 P. M., of Feb. 23, the declination changed 55′ of arc, while on other occasions disturbances not much smaller took place in nearly as short periods of time. Between 3 A. M. and 8 P. M., of Feb. 25, there was another period of violent disturbance, for in the interval 6.50 to 7.20 A. M., the change amounted to 1° 7′. The mean value of the declination for this period, taken by days, shows an increase over the normal on Feb. 20, 21, 25, 26, 27, 28, and March 1, and a decrease on Feb. 22 and 23.

Regarding the horizontal force, it appears that from 11.40 P. M., on Feb. 20, to 10 P. M., on Feb. 21, the force was much below its normal value, and the variations in force during this time were large. Also between 5.30 P. M., of Feb. 22, and 3.30 A. M., of Feb. 24, there was a period of violent disturbance, the force being again below its normal value. Again, between 5.20 A. M. and 8.30 P. M., of Feb. 25, was a period of violent disturbance. During a portion of this time,—5.30 to 10.40 A. M., of Feb. 25,—the horizontal force was very much below its normal value; at one time as much as .004029, the normal value being about .200000 dyne. The horizontal force, mean value, was below its normal during the whole period, Feb. 20 to March 1.

The vertical force increased on the afternoon of Feb. 21; between 4 P. M., of Feb. 23, and 2 A. M., of Feb. 24, it increased; between 3.50 A. M. and 8 P. M., of Feb. 25, it decreased, and on the afternoon of Feb. 28, it very much increased.

The following account of the magnetic storm, regarding which Lieut. Marsh sent the foregoing data, appeared in the Washington *Morning Post*, of Feb. 27, 1894:—

"During the past week a magnetic storm has been raging over Washington. It is impossible to give the area affected, as Washington is the only place where there are facilities for observing the disturbance. But from what is known of the nature of magnetic storms, it is likely that it extends pretty much over the whole world. A magnetic storm is not a storm in the generally accepted sense of the term, but is an unusual and unaccountable meteorological cyclone that is called a 'storm' for want of a better name. It is one of the things about which not very much is known as yet, but a good deal is hoped for from closer investigation. The place where the disturbance is being watched with the greatest interest is a certain under-

ground laboratory on the top of Observatory Hill, above Georgetown, where the Naval Observatory now has its quarters. The experimental work there is carried on by Lieut. C. C. Marsh, and aside from all other interest attaching to it is noteworthy as the only observatory of the kind in the United States. The magnetic needle being such a delicate instrument, the observations are isolated as much as possible from all sources of disturbance. Of these the greatest are changes of temperature and moisture. So the laboratory on the hill is really a vault underground floored deep with cement and concrete, and cut off by double brick walls with a five-foot air space between from the outside ground. It is really a brick vault about twenty feet square inside another vault. Here the temperature is kept at an almost absolutely even figure by an ingenious device. There is not a variation of one degree in the course of a year. The escape ventilation of the observation vault is through a still air chamber, so that there is no direct connection with the outer air, and the fresh air that is brought into the place is carried through a box in which there is sulphuric acid, which absorbs all the moisture.

"The observations themselves are no less ingenious. In the middle of the vault there is a dark box mounted on top of a granite pillar, and in this there are three cylinders on which there is wound sensitive paper such as is used by photographers. These cylinders revolve by clock-work once in twenty-four hours. On the three sides of this dark box there are three other granite pillars, on the top of each of which there is mounted a magnetic needle. One of these is to measure the declination, or the amount that the magnetic north varies from the true north, and the other two are to measure the horizontal and vertical variation, or 'dip' of the needle. This is accomplished by means of mirrors and reflected light. On the top of each granite pillar, and directly under the needle, there is a semi-circular mirror, somewhat larger than a dollar, and a ray of light from a shaded gas jet reflected on this mirror is thrown through a long tube into the dark box, and rests on one of the sensitive cylinders. This mirror is, of course, as steady as the earth itself, so that the pin-point of light resting on the revolving cylinder draws a perfectly straight line around it, as the cylinder makes a complete revolution. Every two hours a shutter falls and cuts off this light for five minutes, so that there is a break in the line. Then, just above this stationary mirror is another of the same sort, which is attached to the end of the magnetic needle, and, as the needle moves, the ray of light, of course, moves on the cylinder in a curve that corresponds exactly to the movement of the needle, so that it is, in fact, as though there were a pencil on the end of the needle acting directly on the paper. The breaks in the base line, as the line drawn by the stationary mirror is termed, give the time at which each variation of the needle occurred, and by comparing the two lines and measuring the distance between the base line and the needle line, the exact variation of the needle in degree can be obtained.

"Usually the variation for the day is slight, resulting in a slightly wavy line, but for the past week, during this storm, the needle has been keeping up a regular ghost dance of jagged lines like the fire points in the aurora,

with whose appearance the variations of the needle is in some way connected. . . .

"The principal fact that is definitely known in regard to the variation now is that it is intimately connected with the appearance of the aurora and the presence of sun spots. It is thought, with good reason, that the meteorological work of the future will depend largely on observations of the magnetic needle, and Prof. Frank Bigelow, of the Weather Bureau, has plotted a curve of needle variations for a series of years past which has been found to correspond, in a remarkable degree, to curves of temperature, barometer readings, and wind velocities for the same period. It is certain that there is much to be gained by continuous observations at the present station, and it is the earnest wish of Lieut. Marsh, by whom the present observations are being made, that the government should establish a station in Alaska or some of our northern possessions, to study needle variations under the very arch of the aurora, where the disturbances of this sort are the most marked. There has been for some years a magnetic observatory at Toronto, and one was in existence for some time at Los Angeles, Cal., and from simultaneous observations at the three stations, it was found that there was a most remarkable coincidence of variation at the different points, the different curves from the recording instruments falling almost exactly on one another when laid down together.

"The work has proved the utter unreliability of compass surveying, over which so many lawsuits are now pending in the older States where this system of land measurement was formerly much in vogue. In regard to the value of the experiments to navigators, it may be seen that, as the variation of the needle corresponds closely with the reading of the barometer, there may, in this way, be a check established on the variation of the needle in high latitudes, where now it is practically useless to the seamen."

The Roumanian Weather Service. — The Roumanian Weather Service was inaugurated in 1883, under a law promulgated on March 30 of that year, which created a Ministry of Agriculture and Commerce, a part of whose duty was to consist in establishing meteorological stations. In the budget of the Minister of Agriculture for the year 1884–5, a sum of ten thousand francs was included, for the creation of a meteorological service. Dr. Stefan C. Hepites, who was then at Dortmund, in Germany, on business connected with the Roumanian railways, was asked to undertake the formation of this service, and to prepare himself for his work by visiting various German observatories, especially that of Hamburg. This task Dr. Hepites at once undertook, with the greatest enthusiasm. He visited the observatories at Hamburg, Copenhagen, Berlin, Brussels, Paris, Zurich, and Vienna, and on July 18, 1884, was appointed Director of the Meteorological Institute of Roumania. He established several stations as soon as possible, and on Dec. 10, 1884, was in a position to announce to the foreign weather services the establishment of a meteorological service in Roumania.

The commencement of n eteorological work in Roumania, as elsewhere, was attended with considerable difficulties, but the number of observers

steadily increased. In 1888 a new building for the central station at Bucharest was purchased. In 1892 the publication of a "Monthly Bulletin," containing the observations made during each month, was begun, previous publications of the service having appeared in the "Annals of the Roumanian Academy." At the beginning of the year 1893 there were 88 stations regularly enrolled. Of these one was of the first order, 20 of the second, two of the third, and 65 of the fourth. On Nov. 10, 1893, there were 140 stations on the list, of which one was of the first order, 22 of the second, one of the third and 116 of the fourth. The sums voted for the service yearly have increased from 10,000 francs in 1884-5 to 72,980 francs in 1893-4. The publications issued by the Roumanian Meteorological Institute have been many, and include instructions to observers; annual reports on the work of the Institute; articles on the climate of Bucharest, etc. The "Monthly Bulletin of Meteorological Observations" is in its second year, and the "Annals of the Meteorological Institute of Roumania" in their eighth. Among the latest publications of the Institute is a historical notice of the Roumanian Weather Service by the director, Dr. S. C. Hepites.* From this account the foregoing facts are taken. Other recent publications are as follows: *Revue Climatologique Annuelle, Année* 1891; *La Pluie en Roumanie; La Pluie en Roumanie en* 1891; *Le Climat de Sulina d'après les Observations Météorologiques de* 1876 *à* 1890; *Le Verglas du* 11 *et du* 12 *Novembre,* 1893; *La Prévision du Temps.*

The "Annual Review" gives a general account of the weather in each month, with several tables of temperature, pressure, winds, etc. The rainfall of Roumania is tabulated and described in the two publications on that subject. The climate of Sulina is made the subject of a valuable report. Sulina is situated on the left bank of the Danube, just at the point where it enters the Black Sea. The station was established in 1857 by the European Commission of the Danube, and observations have been regularly carried on since May 19, 1875. The mean annual temperature is 51.6° Fahr. The absolute maximum observed was 98.4° Fahr., and the minimum —11.2° Fahr., which gives a range of 109.6° Fahr. The relative humidity of the air is 76.5°. The precipitation averages 17.28 inches a year, on sixty-four days. June is the wettest month, and February the driest. The maximum rainfall in 24 hours was 2.58 inches. There are in a year 233 clear days and 142 cloudy ones. The prevailing wind is northeast.

An interesting account of a glazed frost is given in the article entitled *Le Verglas du* 11 *et du* 12 *Novembre,* 1893. This frost occurred over a large tract of country, and did much damage to trees and telegraph lines. Dr. Hepites believes that the cause of this phenomenon was not that the rain fell on objects whose temperature was below freezing, but that the drops were in a state of "over-cooling," and froze on touching the various objects on which they fell. The account is illustrated by four views of trees broken by the heavy coating of ice on their branches.

The general question of forecasting is taken up in the last paper mentioned above.

* *Notice historique sur l' Institut Météorologique du Roumanie. Anal. Inst. met. Roum.* Tom. VII., Pt. 2, 1891.

Meteorological Phenomena in Alaska. — In the Thirteenth Annual Report of the Director of the United States Geological Survey there is published a very interesting report entitled "Second Expedition to Mount Saint Elias," in which Prof. Israel C. Russell gives an account of his visit to Alaska in the summer of 1891. From this report, which is full of interest throughout, the following extracts relating to meteorological matters are taken: —

"On perfectly clear days, when there is not a vapor wreath about the mountains — such days sometimes come unexpectedly after weeks of rain or mist — it is difficult to realize the full magnificence of the hundreds of great mountains in the St. Elias region to be seen from commanding summits like the Chaix hills, owing to the absence of shadows and the apparent flatness of the rugged slopes. On such rare, perfect days there frequently comes a change. Cold winds from the vast ice fields north of the mountains are beaten back by warm, moist winds from the south, and cloud banks are formed in long, horizontal bands along the southern slopes of mountains, far beneath their gleaming summits. Sometimes belts of light gray vapor, scarcely dense enough to obscure the rugged outlines beyond, appear on the faces of the precipices and extend for miles on either hand. The mountains under such conditions seem to rise and expand, buttresses and amphitheatres appear where before there were only flat, expressionless walls, and the great peaks seem to awaken and become aware of their own majesty. Usually the first sign of the coming change when the weather is clear is a small cloud banner on the summit of Mount St. Elias. This signal is a warning that can be seen for one hundred and fifty miles at sea. Soon other peaks repeat the alarm, like bale-fires in times of invasion, and Mount Augusta and Mount Cook, and far-away Fairweather fling out their beacons to show that a storm is approaching."

Regarding the effect of solar insolation at high levels, noted on July 24, during the ascent of Mount St. Elias, Prof. Russell writes as follows: "The day of our climb was unusually beautiful. Not a cloud obscured the sky. In the lower world it must have been an exceedingly warm summer day. In the rare atmosphere with which we were surrounded the sun's rays poured down with dazzling splendor and scorching intensity. We wore deeply colored glasses to protect our eyes, but our faces, although tanned and weather-beaten by nearly two months' constant exposure, were blistered by the heat; yet, while our faces were actually blistering beneath the intensity of the sun's rays, our shoes, immersed in the light snow, were frozen stiff. At noon the temperature in the shade was 16° Fahr. The snow was light and dry and showed no indications of softening, even at the surface."

In this JOURNAL, Vol. IX., pages 95, 96, mention was made of the wind-blasts and snow-flurries often noted in front of avalanches in Switzerland, Canada, and other countries where avalanches occur. Prof. Russell notes these accidental winds as occurring in Alaska also. He says: "A great avalanche, starting far above us in the side of Mount St. Elias, came rushing down the roof-like slope with the speed of an express train. From the foot of the descending mass tongue-like protrusions of snow shot out in advance, while above all was one vast rolling cloud of snow-spray. Blue

crevasses which seemed wide enough to engulf the falling snow were crossed without making the slightest change in its course. On reaching the upper lip of a crevasse the base of the moving mass would shoot out into the air, and seemingly not curve downward at all until it struck the slope below and rush on with accelerated speed. The roaring mass was irresistible. Heavy clouds of spray rolling onward, or blown back by the wind that the avalanche generated, became so dense that all beneath was concealed from view. Only a roar like thunder and the trembling of the glacier beneath us told that many tons of ice and snow were involved in the catastrophe. The rushing monster came directly towards us until it poured down on the border of the slope we were ascending, then changing its course, thundered on to the floor of the amphitheatre far below. The cloud of spray rolled on down the valley, and hung in the air long after the roar of the avalanche had ceased, when it did drift away we saw the fan-shaped mass of broken snow in which the avalanche ended looking like the delta of a stream, extending out half a mile into the valley."

Annual Report of the Work of the Saxon Meteorological Institute.— The annual report of the Saxon Meteorological Institute for 1892 has recently been published, under the direction of Prof. Dr. Paul Schreiber, the Director of the Institute at Chemnitz. The activities of the service during the year were varied, and embraced climatological, hydrographic, and phenologic investigations. Dr. Schreiber has carefully studied the so-called "critical days," which a certain weather prophet, Falb by name, has for some years been predicting in Saxony, and has found, after an examination of the records of twenty-seven years, that the theory of Falb has not the least practical value. It appears that the "critical days" are nothing more nor less than the days of full moon, and that these days do not show any special features of precipitation.

The present report contains the usual meteorological data, statistics as to stations, etc. It also contains, as new features, observations made throughout the year on the Fichtelberg (1,213 meters), the highest station in the country, and the sunshine data for the central station at Chemnitz, which was provided with a sunshine recorder last year. The stations of all classes number two hundred and twenty-one. During the year, as heretofore, special attention was given to thunder-storm observations.

The report also has maps showing the distribution of stations, the precipitation for 1892; number of days with measurable precipitation; distribution of snowfall; number of days with snowfall; number of days with snow covering on the ground, and the number of days with "near" thunderstorms. There are also charts showing barograph and thermograph curves with striking changes of pressure and temperature. Most of these oscillations came in connection with thunderstorms.

South American Barometric Standards.— The following series of barometer comparisons was carried out by me in 1893. A Green mercurial barometer, which had been verified by the standards of the United States

Weather Bureau at Washington, was compared with the standard instruments at the principal observatories and at the chief meteorological office in the South American States. Unfortunately, just after my arrival in the United States, in some unexplained way air leaked into the tube of the barometer and thereby prevented its final comparison with the Washington standard. Although, for this reason, the value of the comparisons is diminished, yet the close agreement of the several South American normal barometers with one another makes it probable that the portable barometer remained unchanged while in South America.

COMPARISONS OF SOUTH AMERICAN BAROMETERS.

Place.	Date.	Designation of Standard.	Deviation of Green (U. S. Signal Service) No. 483.
	1893.		Inch.
Arequipa, Peru . . . (Harvard Obs'y.) Alt. 8,060 feet.	March.	Green, No. 2995. " No. 3185. N. B. These instrs. are similar to U. S. S. S. No. 483, and had not been tested since their arrival in Arequipa two years before.	+ 0.007 + 0.011
Santiago, Chile . . . (Nat. Obs'y.) Alt. 1,703 feet.	April.	Grosch. (Constructed about 1860; adjusted by maker in 1881.)	— 0.002
Córdoba, Argentina . . . (Met. Office.) Alt. 1,434 feet.	May. June.	Negretti and Zambra. No. 991. N. B. This instr. agrees closely with sub-standard Tonnelot, No. 2450.	— 0.005 (Mean of 12 readings.)
Rio de Janeiro, Brazil . . (Nat. Obs'y.) Alt. 217 feet.	June.	Fuess, No. 956. Casella, No. 1606.	— 0.011 (Mean of 4 readings.) — 0.010 (Mean of 4 readings.)

N. B. A plus (+) sign indicates that the Signal Service Green read higher than the compared standard, and a minus (—) sign indicates that it read lower.

A. Lawrence Rotch.

The Thunderstorms of Saxony. — In this Journal for February, pages 436–8, there was published an abstract of the paper on the Thunderstorms of Bavaria, prepared by Dr. Franz Horn for the Chicago Meteorological Congress. A similar article on the Thunderstorms of Saxony, also prepared for the Chicago Congress, by Dr. Paul Schreiber, Director of the Saxon Meteorological Institute, has recently been published in pamphlet form.*

* General-Bericht ueber den gegenwaertigen Stand unserer Kenntnisse ueber Gewitter und die begleitenden Erscheinungen im Koenigreich Sachsen, von Prof. Dr. Paul Schreiber. 8vo. Chemnitz, 1893. Pp. 15. Pl. II.

The following summary of Dr. Schreiber's report is herewith presented: The inauguration of thunderstorm observations in Saxony came in the year 1864, when about twenty stations reported, but the newer systematic observations were not undertaken till 1884–5, about one hundred and forty observers being now regularly enrolled. The observations for the years 1885–1891 show a yearly average of one hundred and fifteen thunderstorm days, which are distributed through the several months as follows: —

January, 1.	April, 14.	July, 26.	October, 3.
February, 1.	May, 20.	August, 16.	November, 1.
March, 4.	June, 19.	September, 9.	December, 1.

This table shows a maximum in July, and a secondary maximum in May. By a comparison of the number of thunderstorm days and the number of reports on these days, it is found that the thunderstorms of Saxony are seldom very extended, but in the great majority of cases are local phenomena.

The time of first thunder was taken as the time of the commencement of the thunderstorms, and from a tabulation, it is seen that 19% of all the storms begin in the morning (12 P. M. to noon) hours and 81% in the afternoon (noon to 12 P. M.). The time of greatest frequency is 3 to 4 P. M.; that of least frequency 3 to 4 A. M. The extremes are, therefore, exactly twelve hours apart. The attempt to draw isobronts, or lines joining places at which thunder was first heard at the same time, was not possible, but some interesting facts have been brought out in connection with thunderstorm districts (*gewitterbezirke*). These districts are found to develop, join, change their forms, divide and disappear.

An interesting table of the number of lightning strokes that have reached buildings in each year from 1866 to 1892 shows an increase in the figures for each pentad. During the seven years 1885–1891, 9% of the hail storms came in the morning, and 91% in the afternoon hours; the maximum frequency of hail comes between 3 and 4 P. M., as in the case of thunderstorms. Hail comes with 57% of the thunderstorms; it is most frequent in July, but more of the June thunderstorms are accompanied with hail than those of July. On an average hail falls on sixty-six days in a year. Charts have been drawn to show the frequency of hail over the kingdom, and the number of hail reports in the years 1885–1891. The former chart seems to show that topography has a marked influence on the distribution of hail.

Annual Meteorological Summary for the State of Mississippi during 1893.* — The records of the Mississippi Weather Service for 1893 give for the State at large a mean temperature of 64.2°, which exactly coincides with the normal temperature deduced from past observations. In North Mississippi the mean was 62.2°, which was 1.6° in excess of the normal for that section. The mean for South Mississippi was 65.4°, or just half a degree below the normal for the southern counties. The highest local annual mean was 67.5° at Pearlington, and the lowest was 61.1° at Batesville, mak-

* The official summary, published by the State Weather Service.

ing a difference of 6.4° between the annual means of the extreme northern and extreme southern counties. The highest temperature recorded during the year was 108° at Columbus on the 28th of July, and the lowest was 3° below zero at Batesville on the 20th of January, thus giving an absolute range of temperature for the State of 111°. This exceeds the absolute range of twenty years of observations at Vicksburg, within which time the extremes of 101° in 1881 and 3° in 1886 are found, making a range of 98°.

The mean annual precipitation for the entire State was 50.70 inches, and occurred in the form of rain, hail, sleet and snow. Compared with the normal annual fall, the past year has been deficient in moisture to the amount of 5.29 inches. The mean annual fall for North Mississippi was almost identical with the State average, and was 3.05 inches below the usual yearly fall in that section. In South Mississippi the twelve months gave a mean total of 55.32 inches, which is 7.39 inches below the established normal for the lower counties. The means for the northern and southern sections are based upon the complete records of six selected stations in each division. The greatest local annual precipitation was 63.16 inches at Batesville, and the least 40.17 inches at Agricultural College. Both extremes are reported from the northern portion of the State, and occurred at stations within a hundred miles of each other. A complete record at Kosciusko would probably have marked it as the driest station during the year, since the precipitation there during eleven months measured but 33.33 inches. Heavy snows occurred over the greater portion of the State from January 17 to 19. The heaviest fall reported was fourteen inches at Booneville, while a depth of four and a half inches was reported as far south as Hattiesburg. Traces of snow fell at Water Valley in February, at Pontotoc, Palo Alto, and University in March, and at University and Water Valley in December, but January had the only noteworthy snowstorm of the year. Sleet fell within the State limits in January, February, and November, and hail occurred in January, April, May, June, July, August, and December. Hail storms were general throughout the interior portions of the State about the middle of April.

The dates of last killing frost in spring and first killing frosts in autumn naturally vary with the latitude of the voluntary stations. Moss Point reports its last killing frost in spring at an earlier date than any other station, namely, on March 4. March 5 and 6 carried the line much farther northward, and the 18th and 19th completed the frost record except at a few stations, such as University, which reported its last killing frost on March 29, and Kosciusko and Crystal Springs, where the record was concluded on the following day. No killing frosts occurred in April. In the autumn, October 15 and 16 gave the first killing frosts at many stations in the northern and central districts. Two weeks later, on the 29th and 30th, killing frosts again occurred in the same sections and extended their scope somewhat into adjacent districts, but it was not until November 15 that the frost line had passed southward over the greater portion of the State. A narrow strip of country along the Gulf Coast continued exempt until in December, when freezing temperatures on the 3d and 4th at Biloxi witnessed the final supremacy of killing frosts in every portion of the State.

Royal Meteorological Society. — The monthly meeting of this Society was held on Wednesday evening, February 21, at the Institution of Civil Engineers, Westminster; Mr. R. Inwards, F. R. A. S., president, in the chair. Mr. R. M. Barrington, M. A., LL. B., Mr. C. G. L. Cator, and Mr. H. Owen were elected Fellows of the Society. The following papers were read: —

(1.) "Temperature, Rainfall, and Sunshine at Las Palmas, Grand Canary," by Dr. J. Cleasby Taylor. The author gave the results of his observations during the five years, 1889–93. The island of Grand Canary occupies a position midway between the African continent and the most western of the Canary group. The mountain peaks rise to a little over 6,000 feet, and are about 20 miles from the coast. The chief town and port of the island, Las Palmas, is consequently free from the influence of the mountains. The diurnal range of temperature fluctuates considerably with the variations in wind and sunshine. With a southerly wind (which usually dies down at sunset) the range is increased, but the greater part of the increase is due to a higher day temperature. With northerly winds persisting after sunset, the range may be very slight, particularly if the day has been cloudy. The sea temperature is dependent on causes outside the limits of the archipelago; local presence or absence of sunshine does not cause any difference. A boisterous northerly wind, with a high sea, may cause the temperature to fall quicker than usual, or, if the temperature is rising, to check the rise, but any sudden variation is very rare. The rainfall is not great, though it is spread over a large number of days, the average yearly amount being 8.90 inches. The greater part of the rain falls during October to January, while the period from June to September is practically rainless.

(2.) "Report on the Phenological Observations for 1893," by Mr. E. Mawley, F. R. Met. Soc. This is a discussion of the observations made on the flowering of plants, appearance of insects, and the song and nesting of birds. The year 1893 was in complete contrast to its predecessor, being very forward throughout the United Kingdom. The February and March plants were later than usual in blossoming, especially in the colder parts of our islands, but after this the dates were everywhere in advance of the average, and during the height of the flowering season the departures from the mean were often considerable.

(3.) "Comparative Observations with two Thermometer Screens at Ilfracombe," by Mr. W. Marriott, F. R. Met. Soc. Some exception having been taken to the thermometer screen which has been in use at Ilfracombe for a number of years past, a Stevenson screen was placed at a distance of sixty feet from the old screen in October, 1892, since which date simultaneous observations in the two screens have been made daily at 9 A. M. The results of this comparison show that the temperature deduced from the two sets of observations agrees very closely, the old screen being only 0.3° higher than the Stevenson.

The International Committee of Meteorology. — Dr. H. Wild, President of the International Committee of Meteorology, has sent out a circular

(No. 4) under date St. Petersburg, Feb. 7, 1894, in which he gives the number of votes received by the several candidates for election to the Committee. The voting resulted as follows: Mr. John Eliot received eleven votes; Mr. R. L. J. Ellery, eleven; Mr. W. G. Davis, eleven; Dr. A. Paulsen, eight; M. Folie, one; Mr. Van der Stok, one; and Mr. Carpmael, one. Messrs. Eliot, Ellery, Davis, and Paulsen are therefore elected.

Nearly all the members who have replied have agreed to meet this year in the latter half of August. Six members vote positively for Upsala as the place of meeting. The other members prefer a more central place of meeting, but four of them are willing to go to Upsala. No other city has been proposed. It has, therefore, been decided that the Committee shall meet at Upsala about Aug. 20, 1894. The exact date, hour, and place of meeting, as well as the programme, will be determined later.

CORRESPONDENCE.

DR. VEEDER'S AURORAL RESULTS.

Editor of the American Meteorological Journal: —

It has been somewhat of a surprise to read the following words by Dr. M. A. Veeder, Lyons, N. Y., in the Journal of March, 1894, page 482: "Professor Bigelow has evidently made use of the table of auroras constructed by myself and widely distributed in connection with the papers on the Zodiacal Light and Thunderstorms, published by the Rochester (N. Y.) Academy of Science. It is seen from this table that June 12, 1887, was the first day of one of the periods, and that the days of maximum, obtained by footing up the numbers of stations reporting auroras, are the 3d, 6th, 13th, 17th, 22d, 26th days, the same as given by Prof. Bigelow. This adoption of my results," etc.

The sums of the columns in the table referred to are as follows: —

Day,	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sum,	64	75	94	95	**147**	46	98	**252**	129	128	75	27	31	47
Day,	15	16	17	18	19	20	21	22	23	24	25	26	27	
Sum,	**102**	46	**141**	81	136	134	**145**	55	170	**246**	130	118	66	

The maximum numbers occur on the 5th, 8th, 15th, 17th, 21st, 24th, and it is hoped that there is a way to reconcile this fact with Dr. Veeder's statement that "the days of maximum are the 3d, 6th, 13th, 17th, 22d, 26th, the same as given by Professor Bigelow."

Dr. Veeder has obviously adopted Carrington's sun-spot period of 25.38 days, equivalent to 27.28 days for the synodic period, on the authority of the Greenwich Volumes, for the true solar rotation. My discussion of the variations of the magnetic field, observed at seven European observatories,

has given 24.863 days, equivalent to 26.68 days for the synodic period, as that of the rotation of the sun, which agrees very closely with Carrington's period for the rotation at the sun's equator. So far from having used Dr. Veeder's auroral table, I was not in possession of a copy till after my period had been secured. In its final state, as already communicated in several papers, it depends upon four least square solutions of the important magnetic observations of Europe for the years 1878 to 1889 inclusive. Dr. Veeder ascribes the auroral impulse to the superficial sun spot at the eastern limb, and he is brave enough to say that the energy at the earth is due to electro-magnetic induction, whatever he may mean by that under the physical conditions imposed upon the problem ; hence his assumed forces come to the earth along the plane of the ecliptic in straight lines. In accordance with my analysis, these auroral impulses are symptoms of the magnetic field, whose seat is in the nucleus of the sun, and which approaches the earth at right angles to the ecliptic. It may furthermore be stated that the classification of these auroral numbers on the 26.68 day period is not an unsatisfactory period. It is not possible, in my judgment, to construct any physics of electricity and magnetism that allows this auroral energy to be attributed to individual sun spots. There will, therefore, be no reason for any one in the future, not even Dr. Veeder himself, to suppose that I used his tables originally, or have, at any time, adopted his results.

FRANK H. BIGELOW.

WASHINGTON, D. C., March 7, 1894.

RAINFALL RECORDS AT HONEYMEAD BROOK, DUCHESS CO., N. Y.

Editor of the American Meteorological Journal :—

The time included in the present discussion, Oct. 1, 1883, to Feb. 11, 1894, equals 3,787 days, with a total rainfall, including snow, hail, etc., of 427.11 inches. This would afford a mean daily precipitation of 0.11 inch. The mean daily precipitation for the month of July for thirteen years has been 0.15 inch.

July here has a greater mean rainfall than any other month. The monthly mean declines from July in the order of the months, except that December has a lower mean than January.

After January, the monthly mean declines through April, and afterward rises. May, however, has a larger mean than June. Thus each of the solsticial months breaks the regular order.

By comparing the rainfall as it proceeds through a series of years with the normal for the corresponding period, it is at once seen that the rainfall at most places is unevenly distributed. Periods during the whole of which, the rainfall is above their season's normal may be called *Full Rain Periods*, while the intervening periods of diminished rains may be called *Scant Rain Periods*. These periods are variable in length. The shortest periods are of seven days duration. The longest full rain period here, during the

3,787 days, was 137 days, or from April 1, 1889, to Aug. 15, inclusive. Its total precipitation, 22.10 inches, gives a daily mean of 0.16 inch. This is above the daily normal for July.

The longest scant rain period was 169 days, from May 1, 1886, to Oct. 25, inclusive. Its total precipitation, 11.13 inches, equals a daily mean of 0.06 inch, which is less than April's daily normal, 0.07 inch.

During the whole 3,787 days, the rainfall here has come in forty-three full rain periods and forty-three scant rain periods. The full rain periods have occupied 1,912 days, with a precipitation of 321.82 inches, equalling a mean daily precipitation of .17 inch, or above July's normal; the forty-three scant rain periods, occupying 1,875 days, gave about 100.29 inches, equalling a mean daily precipitation of .053 inch, or less than April's normal. Thus the rainfall of the scant rain periods is not one third as great as that of the full rain periods, although the time has been nearly equally divided between them.

Further than this, a full rain period has been characterized here by an initial and generally continuous rain of not less than .40 inch, often much more; and by a terminal rain of .40 inch or more, also generally continuous. To this continuity there have not been in the forty-three full rain periods as many as five exceptions.

Having noticed that on several occasions the change from a scant rain period to a full rain period, or the contrary, had occurred very near to some one of the four lunar instants, namely, of the conjunction or new moon, of the first lunar quarter, of the opposition or full moon, or of the third or last lunar quarter, I became interested to learn how close these relations are in time. Going back, then, to Oct. 1, 1883, to obtain a reasonable basis, I have made a very close and careful study of the whole matter, involving much labor. The results are given herewith. The mean interval between the commencement of a full rain period and its related lunar instant for the whole forty-three periods is 29.2 hours. For fourteen of the forty-three periods, the rain began before the lunar instant, the mean interval having been 4.7 hours. For seventeen of them, which began after the lunar instant, the mean interval was 12.9 hours.

There were seven of the forty-three periods with an interval of more than forty hours. These are rejected from consideration as having an abnormally long interval, excepting in giving the before-mentioned mean interval of 29.2 hours for the whole forty-three.

The remaining thirty-six full rain periods are typical, with a mean interval of 7.9 hours. Thirty-one of these typical beginnings had a mean interval of 9.3 hours.

Five of the forty-three full rain periods had intervals of less than an hour, some of them less than a quarter of an hour, while once the rain began within five minutes of its lunar instant. Of these five which are put down without interval, some began squarely with a pronounced rain and some with a rainy mist several hours before the lunar instant, very light at first, but growing heavier, so that it was difficult to decide exactly when the actual rain began.

The duration of the forty-three full rain periods on the average has been a trifle greater than that of the corresponding lunar interval, but it is frequently shorter by two or three days. The beginning of the full rain period comes somewhat more frequently after the lunar instant than before it. There is thus indicated a slight tendency in the full rain period to drag behind; but the fact that the mean interval between the lunar instant and the beginning of the full rain periods has been but 29.2 hours for the whole forty-three, including the seven abnormal cases, distinctly shows the close relations of the full and the scant rain periods to the four lunar changes. Several other particulars of these relations have been worked out, but for the present mention of them is omitted.

It is quite unnecessary to assume from the foregoing that the moon influences the weather or even the rainfall. As in case of the shore tides of the ocean it is a matter of the *relative position* of the three bodies,—sun, earth, and moon, through which the forces concerned bring out the results.

JAMES HYATT.

BANGALL P. O., DUCHESS COUNTY, N. Y.,
Feb. 19, 1894.

BIBLIOGRAPHICAL NOTES.

OBSERVATIONS ON MONT BLANC.

Annales de l' Observatoire météorologique du Mont Blanc (altitude 4,365 m.). Publiées sous la direction de J. Vallot, fondateur et directeur. I. Paris. G. Steinheil, éditeur, 1893.

These *Annales*, as M. Vallot states in the preface, are intended principally for the publication of the researches made at his observatory. They will appear irregularly, according as sufficient data are collected, and will be distributed to interested persons. The memoirs which may be published will relate to meteorology, terrestrial physics and physiology at high altitudes, besides researches on the glaciers and topography of Mont Blanc.

The Observatory at the Rocher des Bosses (14,350 feet), erected by M. Vallot in 1890 and considerably enlarged since, has cost with the instruments $13,000, all of which expense, together with that of the *Annales*, has been borne by M. Vallot. The observatory is generously placed gratuitously at the service of any scientist who may wish to work there, and this offer has already been accepted by four Frenchmen, three Swiss, one German, one Italian, and one American, the latter being the reviewer, who has sojourned there three times. The tourists' refuge, which was formerly a part of the observatory, is now a separate building, giving more room and quiet for the observatory. A description of the latter in 1890 will be found in this JOURNAL, Vol. VII., No. 9, and of it and the other cabins on Mont Blanc in 1892, in Vol. IX., No. 9.

Turning to the series of memoirs in M. Vallot's quarto volume of one hundred and eighty-seven pages, we have first a general account of the first series of meteorological observations made at the summit of Mont Blanc (15,780 feet), at the Grands Mulets (9,875 feet), at Chamonix (3,395 feet), and at Geneva (1,335 feet), the data for the first three stations having been obtained from the self-recording barometer, thermometer, and hygrometer of Richard Brothers, supplemented by eye readings of standard instruments. In 1886 M. Vallot commenced his ascents of Mont Blanc, and in 1887 he passed three days on the summit making meteorological and other observations and installing the self-recording instruments, as he also did at the Grands Mulets. These instruments were frequently inoperative between July 17 and September 11 when it was attempted to keep them in action. Thus, at the summit, the barograph recorded only on fifty-four days, and the thermograph on thirty days, while, on account of an accident, the hygrograph gave no records. The corrected curves of the instruments at the various stations are reproduced.

The first memoir is a discussion of the temperature correction for the Fortin and aneroid barometers, and this is followed by perhaps the most important one in the volume, — a study of temperature, pressure, and humidity, on Mont Blanc and at the lower stations, as deduced from the two months' observations during the summer of 1887, already mentioned. For the first element, the influence of the ground in raising the air temperature is shown to diminish with the altitude, so that the air over the summit of Mont Blanc probably has a lower temperature than the free air at the same height. The decrease of temperature with altitude is dependent on the hour of the day up to about three thousand metres; in July and August it averaged 1° C., for one hundred and sixty-four metres, which agrees with De Saussure's determinations for the Col du Géant. The diurnal periods of relative humidity and atmospheric pressure on Mont Blanc are interesting, and the reviewer has already called attention to them at the meeting of l'Association Française pour l'Avancement des Sciences in 1890 (JOURNAL, Vol. VII., page 318). The diurnal variation of relative humidity is seen to be quite different from its *régime* in the valley. Thus, while at Chamonix the maximum occurs about 4 A. M., and the minimum about 2 P. M. at the Grand Mulets the maximum is displaced to 7 P. M., and the minimum to 10 A. M., and on Mont Blanc, from the few eye observations, there would seem to be nearly complete inversion of maximum and minimum. The theory which these facts support is, of course, that when the sun first shines in the valleys, it produces an ascending current carrying the water-vapor to higher regions which ought, therefore, to become damper as the day advances, and the humidity should decrease after sunset, when the vapor sinks into the valley. The diurnal period of the barometer is studied for five stations ranging from Geneva to the summit of Mont Blanc. From these curves it is seen that, although the maxima and minima occur at about the same hours, yet their relative intensities vary. Thus, at low levels the greatest difference is between the morning maximum and the evening minimum, but the difference diminishes progressively with altitude, so that on the summit

of Mont Blanc the afternoon minimum has been gradually filled up and tends to disappear; the morning maximum at the same time has been retarded and nearly displaces the usual afternoon minimum. The Mont Blanc curve is, therefore, reduced virtually to one morning minimum and a long afternoon maximum, with a slight minimum between 7 and 8 P. M. The author concludes that, of the four inflexions at low levels, two are caused by the lower part of the atmosphere, and that the theory ascribing the daily fall of the barometer to an increase of heat must be modified so as to explain why, when the greater part of the variations due to the atmosphere is diminished, the increase of heat produces a rise of pressure. M. Vallot does not seem to be aware that Dr. Hann has investigated this subject thoroughly in his "Untersuchungen über die taegliche Oscillation des Barometers" (Vienna, K. Akad. der Wiss. Math.- Naturw. Classe, Bd. LV., LIX.), where he states from theoretical considerations that the daily barometer curve on Mont Blanc should correspond closely with that of temperature. The curves obtained from two months' records of temperature and pressure on Mont Blanc seem to confirm this theory.

The other meteorological memoir by M. Vallot is a study of the storms on Mont Blanc from the barometric curves there, at Chamonix and at other stations. The author believes that there are in the atmosphere two regions quite distinct, — one below the nimbus, characterized by rain and sinuous movements of the barometer, and the other above the nimbus marked by wind, vertical movements of the barometer, white fog and snow. A special study of the barometric traces on Mont Blanc was made. During gales there is a thickening of the curves caused by the rapid oscillations of the pen of the barograph. These oscillations have been studied in detail by the statoscope of Richard. This instrument has an air reservoir capable of being connected with a metallic manometer, which records on a rapidly moving drum the pressure multiplied eleven times the mercurial. In some of the traces reproduced, the change of pressure has amounted to nearly five millimeters in the space of a few seconds. M. Vallot does not attribute these oscillations to the dynamic force of the wind or to the rarefaction of the air in the building, but considers them to be due to a series of conical whirls about vertical axes, succeeding each other with rapidity, and sees in them an experimental proof of Mr. Faye's theory of the origin of cyclones in the upper region of the atmosphere as developed in this JOURNAL, Vol. VI. In opposition to M. Vallot's conclusions, the reviewer would state that Mr. Clayton showed in *Science* in 1886 that the rapid pressure changes at Blue Hill during high winds were largely caused by the compression or rarefaction of the air in the room in which the barograph was situated.

Two other memoirs relate to the movement of the glaciers and snow on Mont Blanc, the latter indicating that no edifice on its summit will be stable. M. Vallot also gives the report of M. Imfeld, the engineer charged by M. Eiffel in 1891 to ascertain by tunnelling whether there was rock near the summit which would furnish a foundation for M. Janssen's proposed observatory. In this tunnel M. Vallot made interesting researches, among them being a determination of the mean annual air temperature on Mont Blanc

which he places at slightly above —16.7° C. (1.9° Fahr.), which is considerably lower than the estimate of the reviewer. (JOURNAL, Vol. IX., page 412.)

A translation of a paper by Dr. Egli-Sinclair on mountain sickness and two topographical papers by M. H. Vallot complete the varied list of those in this first volume of *Annales*, which anticipates the publication of any results from M. Janssen's much talked of observatory on the summit of Mont Blanc. A report on M. Vallot's work, as exemplified in this volume, was presented to the French Academy of Sciences, Jan. 22, 1894.

A. L. R.

CURRENTS OF THE GREAT LAKES.

MARK W. HARRINGTON. *Currents of the Great Lakes, as deduced from the Movements of Bottle Papers during the Seasons of* 1892 *and* 1893. U. S. Department of Agriculture, Weather Bureau, Bulletin B. Washington, 1894. Pages vi., plates VI., 24 x 18 inches.

The work of the Weather Bureau in the interests of commerce on the Great Lakes has recently developed new energy, and, as a result, we have had two publications of considerable importance in connection with the currents of these lakes. The first is the "Wreck Chart of the Great Lakes," issued early in 1892, showing the positions of wrecks due to meteorological agents. The second is Bulletin B, recently issued, on the "Currents of the Great Lakes," by the Chief of the Weather Bureau. The study of the lake currents naturally grew out of the results obtained in the wreck chart, for it was seen that a striking feature of that chart was the clustering of wrecks in certain parts of the surface of the lakes.

The method pursued in the investigation of the lake currents was the same as that already frequently employed in the case of the ocean currents viz., that of bottle papers. The bottles are thrown overboard at certain definite points, the time and place of floating being written on a paper inside the bottles, and when picked up the time and place of finding are also marked on the paper. This plan has been quite successfully followed in the case of the ocean currents, and has been found to work equally well on the lakes. A useful scheme was adopted in order to facilitate the work of the masters of vessels in floating the bottles. The lakes were divided into a series of relatively small squares, which were reduced to a map and a copy of the map furnished with the bottles, so that the place of floating could readily be recorded in the proper square. About ten per cent of the bottles were recovered, most of them on shore.

The results of the charting are very instructive and of great value, although the conclusions relate only to the summer months, the finds of bottles floated in the autumn and found in the spring having been thrown out of consideration. Prof. Harrington groups the Lake currents under four heads : A. *Body Currents :* The general flow of the Lake waters toward the outflow, continuous throughout the year, and of slight velocity. B. *Surface Currents due to the Prevailing Winds ;* It appears that two thirds

of the winds at the Lake stations of the Weather Bureau during the year are westerly winds ; during the months, May to September, fifty-six per cent are westerly winds. These westerly winds would cause surface currents from the west, or in the same direction as the body current, in the case of the lakes lying east and west, and in the case of the lakes lying across the direction of the wind, the surface drift would be across the lake from the west. The frequent variations in wind direction, barometric changes, etc., also have influence on the currents, the former being of considerable and the latter of minor importance. C. *The Return Currents :* In the cases of three lakes (Superior, Michigan, and Huron), the main current hugs one shore, while in Erie and Ontario this is not so marked a feature. This movement of the water, due to a combination of the body and surface currents (A and B), necessitates a return current, which, when the lake is broad, as in Superior and Huron, or lies across the wind, as in Huron and Michigan, makes a general whirl in the lake. When the lake lies with its long axis in the direction of the wind, as in the case of Erie and Ontario, the return currents are found to break up into smaller whirls along the large bays, on either side of the general current. D. *Surf Motion :* The result of the floating of a bottle into the region of surf is that the bottle is soon carried ashore, in the direction in which the surf is moving.

Regarding the velocity of the currents Prof. Harrington believes that this varies, in a general way, between four and twelve miles a day.

We have not space to follow Prof. Harrington further in his interesting conclusions. Each lake is taken up separately and the peculiarities of its currents are described, and six excellent charts are given, showing for each lake the probable courses of the bottle papers for 1892 and 1893. These charts are very clear, and are unencumbered with any unnecessary data, The sixth chart is a generalized current chart of all the Great Lakes, and presents the facts reached in the investigation in a striking manner. The Bulletin is one which will be of especial value to the shipping interests of the lakes, but students of physical geography generally will find it well worth examination.

THE DEVELOPMENT AND MOVEMENT OF CYCLONES.

C. F. MARVIN. *The Development and Movement of Cyclones, as shown in the Morning and Evening Weather Maps, April* 2–6, 1892. U. S. Department of Agriculture, Weather Bureau. Washington, 1893. Ch. 10, with text.

A useful set of charts, with explanatory text, has been published by the Weather Bureau. The object of the publication is to show certain facts as to the development and movement of cyclones, as illustrated in the morning and evening weather maps of April 2 to 6, 1892. Prof. C. F. Marvin has prepared the text. The charts selected present several of the typical weather conditions which we experience during the passage of a well-marked

cyclone across the United States, such as the flow of warm, moist southerly winds from the Gulf; the rise of temperature southeast of the centre of low pressure; heavy precipitation over a large part of the country; a cool wave following in the rear of the cyclone, etc. The cyclone in question moved from Colorado northeastward to the Lakes and thence down the St. Lawrence Valley.

The charts are well suited for use in instruction, and the explanatory text is clear and easy for those unacquainted with the subject to understand. The preparation of such a series of charts, to illustrate the main facts of weather changes, is a simple matter, which may well be undertaken by school teachers. By taking the daily weather maps as issued by the Weather Bureau, and by coloring the isobars in blue and the isotherms in red, drawing the tracks of the cyclonic areas, adding long arrows to show the general flow of the winds, etc., any teacher may easily prepare sets of charts, which will be found very useful in instruction and will furnish interesting and profitable employment for the scholars.

REPORT OF THE CHIEF OF THE WEATHER BUREAU FOR 1891 AND 1892.

Report of the Chief of the Weather Bureau. 1891–92. U. S. Department of Agriculture, Weather Bureau. 4to. Washington, 1893. Pp. 528. Pl. IV.

The Report of the Chief of the Weather Bureau for 1891–92 is the first volume of meteorological data published by the Weather Bureau. It contains the results of observations made during 1891 and 1892, continuing the series heretofore published by the War Department, and other climatological tables of general interest and importance in connection with the current work of the Bureau.

The need of crowding two years' observations into the space intended for one has made it necessary to omit the detailed hourly and twice daily observations. The volume contains the results of observations for 1891 and 1892, and in addition tables of monthly and annual normal pressure, temperature, and precipitation. Prof. C. F. Marvin contributes a description of the instrumental equipment of observing stations, illustrated with cuts of the various instruments, including the new weighing rain and snow gauge; Prof. Cleveland Abbe has a paper on Instrumental Corrections; Prof. Frank H. Bigelow presents a Report on the Relations of Solar Magnetism to Terrestrial Magnetism and Meteorology; Prof. Carl Barus, a Report on Condensation of Atmospheric Moisture, and Prof. H. A. Hazen, on Local Storms in the United States during 1890, 1891, and 1892, and on A Balloon Ascension. Mr. Alex. McAdie contributes a report on Casualties due to Lightning.

ELECTRICAL LITERATURE.

ALTHOUGH somewhat apart from our own subject of meteorology, we wish to note the appearance of a new magazine in connection with electrical engineering. It is called "Electrical Literature," and its first number was issued on Jan. 1, 1894. The object of this paper is to present a monthly summary of current engineering literature. The editor is W. M. Stine, and the publisher Fred DeLand, of Chicago. The subscription price is $3.00 a year. The magazine is a neat octavo volume, and the variety of subjects entered in its summary, including, among other things, Lightning and Meteorology, is such that "Electrical Literature" is of value to many persons besides electrical engineers. This new paper is a continuation of the synoptical index which formerly appeared in "Electrical Engineering." The titles in the first number under the heading "Lightning and Meteorology" include Mr. Rotch's "The Highest Meteorological Station in the World" and Prof. Bigelow's "The Periodic Terms in Meteorology due to the Rotation of the Sun on its Axis," both of which articles have recently appeared in this JOURNAL.

ALABAMA WEATHER REVIEW.

WE are pleased to note the appearance of the first number of the *Alabama Weather Review and Agriculturist*, issued Feb. 10, 1894. This publication, like the others of its kind issued by various State Weather Services, presents the usual meteorological data for the last month, together with notes of interest to the observers of the Weather Service in the State. Mr. F. P. Chaffee, Forecast Official for Alabama and Director of the Alabama Weather Service, is the editor of this new paper. The subscription price is fifty cents a year, and the local observers in Alabama should be glad to support so commendable an undertaking. The JOURNAL welcomes the *Alabama Weather Review and Agriculturist* to a place in the ranks of the meteorological publications of the United States.

TITLES OF RECENT PUBLICATIONS,

FURNISHED BY MR. OLIVER L. FASSIG, LIBRARIAN, U. S. WEATHER BUREAU, WASHINGTON, D. C.

(An asterisk [*] indicates that the publication thus designated has been received by the Editor of this JOURNAL.)

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